Study of Using Mixture of Bintaro and Coconut Shell Charcoal Powder as Pack Carburizing Media on ST 41 Steel

Aji Ridhotullah[1,a)], Rahmat Ashari[2], Sulistijono[3], Rocky Andiana[4] , Yoel Rizky[5]

Material and Metallurgical Engineering, Institut Teknologi Kalimantan, Soekarno-Hatta KM. 15 Balikpapan Utara, Balikpapan 76127, Indonesia

[a)] 06131006@itk.ac.id

Abstract. Pack carburizing is one method of adding carbon into the steel surface. This method is done to improve the mechanical properties of steel so as to reduce the risk of material failure due to static and dynamic load. It has been done in this research about pack carburizing with mixed bintaro charcoal media with coconut shell on ST 41 steel. Carburizing method is done by heating steel which is given a mixture of charcoal at 900 celsius temperature with variation of holding time (1h, 1.5h, 2h) And variation of the charcoal mix ratio with $BaCO_3$ (90: 10, 85: 15, 80: 20). Conducted testing of microstructure, jominy, and the composition so it is known that the mixture of bintaro charcoal and coconut shell quite effectively used as a media pack carburizing. It can be seen that the hardness value of carbon steel has increased with the highest value of 65 HRC, metallographic test results showed good carburizing coating with the best thickness value of 30.9 μm, in jominy testing showed the low hardness carbon steel ability increased with the highest distance from the specimen quench-ends about ¾ inch and on the compositional test results showed an increase in carbon content in steel more than 200%.

***Keyword*: ST 41, Bintaro, *Carburizing*, Coconut Shell**

INTRODUCTION

Steel products such as shaft components, gears, chemical pipe valves are common parts that made of steel. In the operational process, that part is of course influenced by static or dynamic load. This causes the steel to be used to have the required characteristics of mechanical properties. Steel with poor toughness and low hardness steel have a significant effect on the machine's operational processes. Failure and damage to the engine components occur as a result of components that have low properties that are unable to accept the load during the machining process takes place.

Physics analysis and mechanical properties of steel by carburizing using coconut shell charcoal have been studied. The results of the study say that the value of hardness is experiencing a good improvement. The microstructure also shows that the phase is ferrite and pearlite. The best result of the study is when the holding time given is 4 hours (Akhmad, 2012).

Alternative pack carburizing media needs have to investigated again. This is because the availability of coconut shell is declining due to demand coconut shell charcoal is often used as a water purifier and cooking fuel. One alternative to coconut shell is bintaro fruit. Bintaro fruit is a type of mangrove fruit that has a content of lignin and cellulose absolutely good (Nurjito & Leman S, 2008).

From the results of the above description, in this study will be studied about the utilization of bintaro fruit charcoal mixture and coconut shell as a media pack carburizing on steel. This study will study the effect of the charcoal mixture on the mechanical properties of low carbon steels. In this study using variation of $BaCO_3$ composition as energizer carburizing process. So the method used can improve the mechanical properties of the specimens of this study.

MATERIALS AND METHODS

Materials and Tools

The materials that used in this study are ST 41 steel, bintaro fruit charcoal, coconut shell charcoal, and $BaCO_3$

TABLE 1. Composition of ST 41 Steel

C%	Si%	Mn%	P%	S%
0,22	0,14	0,46	0,025	0,025

Specimens Preparation

Initial preparation of ST 41 steel is to cut material into A and B roundbar shape specimens with diameter 25 mm with each length 30 mm and 100 mm.

Charcoal Preparation

Bintaro fruit and coconut shell are produced by 480 celsius heating process in pyrolysis furnace. The charcoal is then poured to 30 mesh.

Pack Carburizing Method

First, coconut charcoal and bintaro charcoal are inserted into a steel box with a ratio of 50:50. Then weighing the mixture of charcoal in the steel box. Result of weight scales of 500 grams were then mixed with BaCO3 according to the variables in the study (80: 20,15: 85,10: 90). Calculation of the ratio of charcoal mixture and $BaCO_3$ can be seen below.

20% $BaCO_3$ = 500 gr x 20/100	15% $BaCO_3$ = 500 gr x 20/100	10% $BaCO_3$ = 500 gr x 10/100
= 100 gr	= 75 gr	= 50 gr
Charcoal Mixture : $BaCO_3$	Charcoal Mixture : $BaCO_3$	Charcoal Mixture : $BaCO_3$
80 : 20	85 :15	80 : 10
500 gr : 100 gr	500 gr : 75 gr	500 gr : 50 gr

Then the ST 41 steel is inserted into a steel box containing a mixture of charcoal and $BaCO_3$. Furthermore, the box will be heated up to 900 celsius (1 hour, 1,5 hour, 2 hour) with cooling in the air in the end. After the cooling process in air has been completed, each specimen is reheated in the furnace to a temperature of 780 celsius (10 minute holding) with a cooling process in water in the end.

Microstructure Test

This test aims to determine the micro structure that appears on the steel before and after the process of packcarburizing. Observations were made to see the microstructure of the surface boundary portion with the center of the sample. This method uses the ASTM E407 standard as an etching reference.

Hardness Test

This test was conducted to determine the hardness of ST 41 steel surface before and after pack carburizing. The test was idented at four points on the carburizing surface of specimen B that had been done pack carburizing. Hardness test will used with rockwell C method with ASTM E 18 testing standard. This hardness testing process can be seen in fig 2.

Jominy Test

This test is performed to determine the properties of ST 41 hardened steel before and after pack carburizing process. This test is performed on specimen A with jominy tool according to ASTM A255 standard. Prior to the furnace heating, a specimen preparation will be used as shown in Figure 2 with the shape of ASTM A255 standard, Furthermore, heated specimens using a heat treatment furnace to a temperature of 780 ° C. Temperature was then held for 10 minutes. Then a hardness test is performed at each point at a distance of 1/16 "at each point by a hardness testing machine.

Composition Test

This test aims to determine the composition of the starting material to be used as a carburizing pack material. This method uses a tool called Optical Emission Spectrometry. This method is done by shooting the test material to know the elements contained in the material. This test uses ASTM A517 standard.

RESULT AND DISCUSSION

Hardness analysis

From the results of hardness values can be seen that the value of hardness is increasing when the pack carburizing process with variation of holding time and variation of $BaCO_3$ composition.

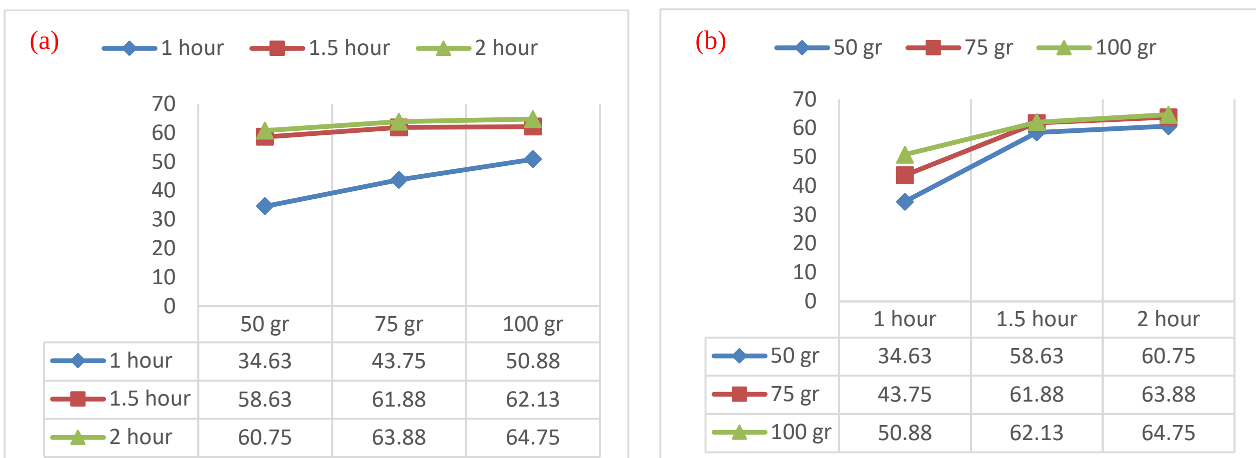

FIGURE 1. (a) Variation of Holding Tine (b)Variation of $BaCO_3$

In the graph in Figure 1a it can be seen that each addition of $BaCO_3$ composition, the hardness value of the steel surface has improved well. Which can improve the effectiveness of pack carburizing process that occurs on ST 41 steel. In the graph in Figure 1b it can be seen that each addition of holding time, steel surface hardness value has increased. This is because the longer holding time, the steel has more time enough and optimal for the process of carbon diffusion into the steel surface. The longer of holding time can also create a homogeneous temperature distribution in the steel during the pack carburizing process.

Jominy Hardness Analysis

From the result of jominy hardness test done, got value from 11 point indentation. $BaCO_3$ and hold time variations have influence on jominy hardness test results

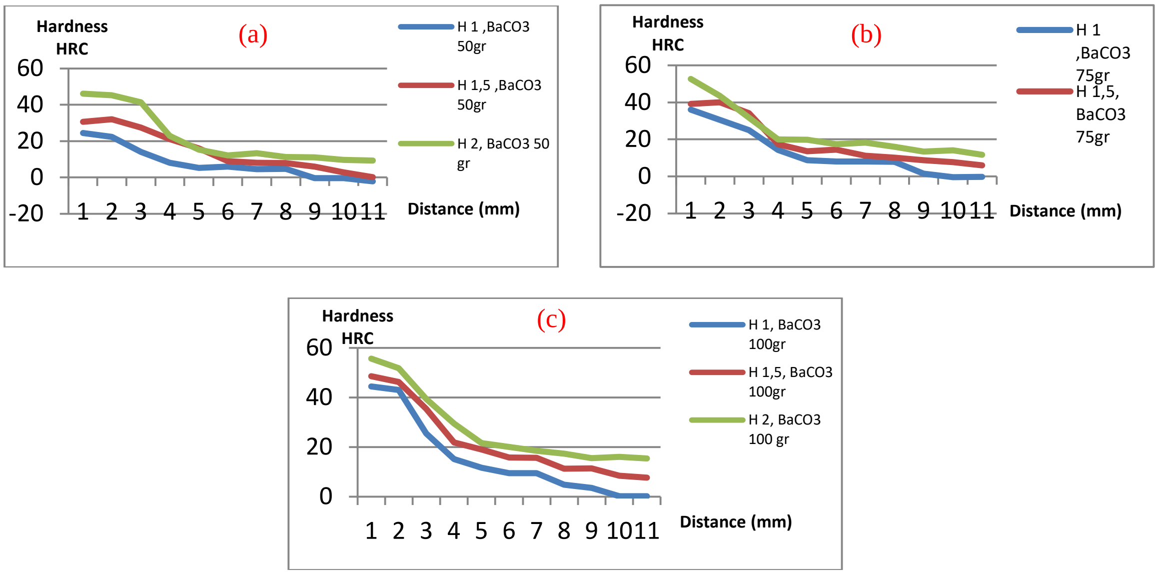

FIGURE 2. Variation of Holding Time (a) 50 gr $BaCO_3$ (b) 75 gr $BaCO_3$ (c) 100 gr $BaCO_3$

From all the charts it can be seen that the longer holding time of the pack carburizing, the greater the hardenability distance. With the addition of holding time, will cause the process of carbon diffusion will be longer. So this will increase the carbon more. The presence of abundant carbon and rapid rate of pendingingan can create a high enough hardness.

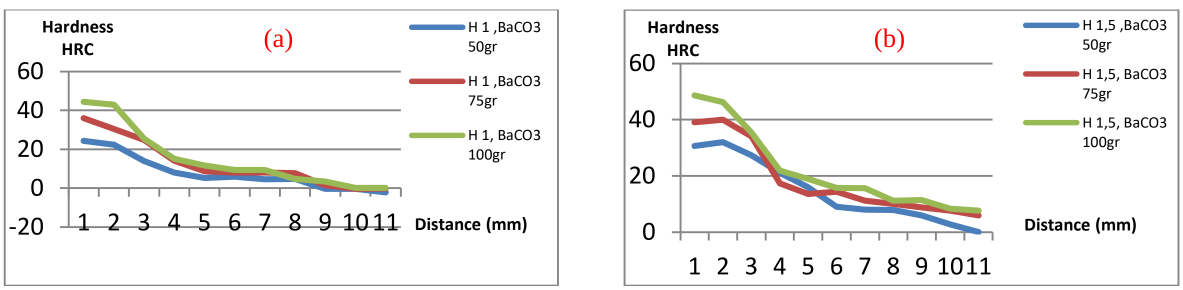

FIGURE 3. Variation of $BaCO_3$ (a) 1 hour (b) 1,5 hour

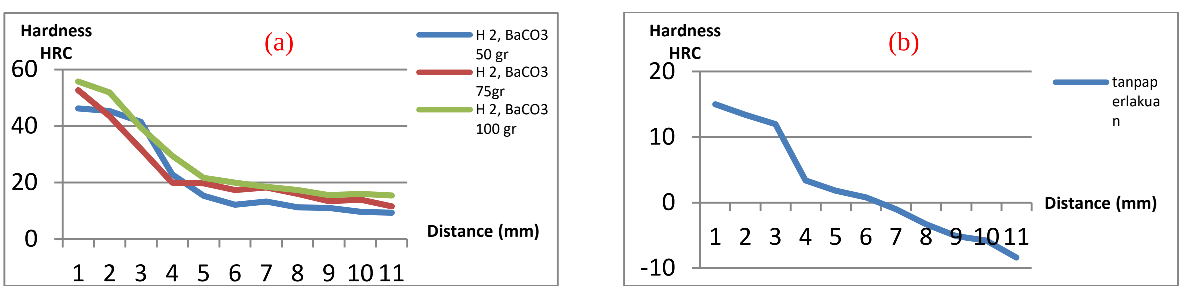

FIGURE 4. (a) Variation of $BaCO_3$ 2 hour (b) Raw Material *Hardenability*

From all $BaCO_3$ variation charts known that when the composition of $BaCO_3$ gets more, hardenability of steel becomes bigger. With the addition of the composition of $BaCO_3$ will lead to an effective process of carbon diffusion. The presence of carbon can create a hardness of up to 50 HRC on material at 1.5 hours with a composition of $BaCO_3$ 100 gr. From all curve of Figure 2 to 4a, it shows that the resulting that joming hardness value has a good improvement when compared to the raw material just have only a hardness value of about 10 HRC as in figure 4b.

Microstructure Analysis

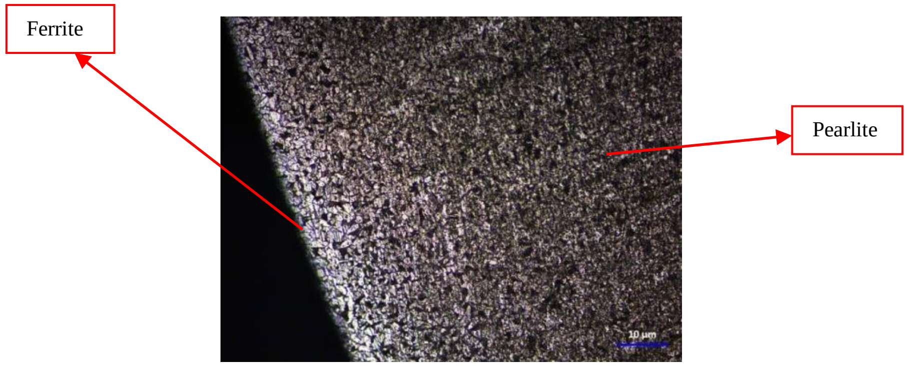

FIGURE 5. Raw Material

Figure 5 is an early ST 41 steel micro structure. Can be seen that dominant ferrite phases and pearlite are formed in microstructure. The dominant ferrite phase proves that the steel is relatively soft.

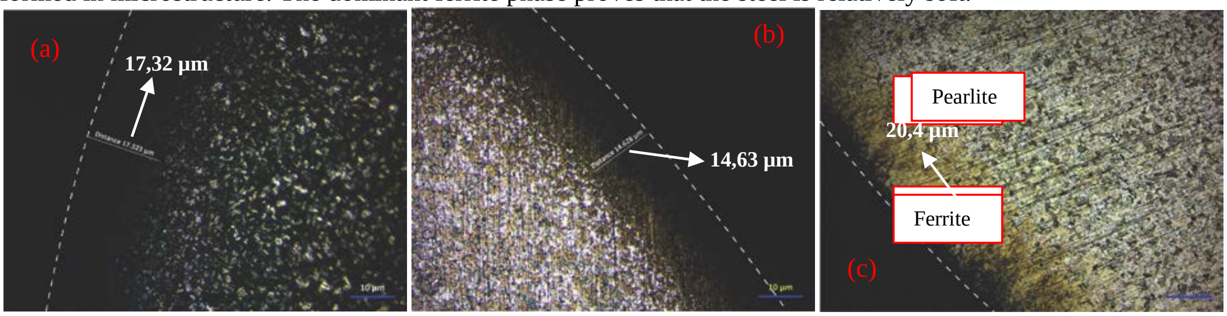

FIGURE 6. Material 1 hour (a) $BaCO_3$ 50 gr (b) $BaCO_3$ 75 gr (c) $BaCO_3$ 100 gr

From these pictures of the specimens can be seen that the microstructure in the raw material changed due to pack carburizing process. This is evidenced by a carburizing layer formed. This shows the presence of abundant carbon on the surface due to carbon diffusion in the process of steel pack carburizing (Kuswanto, 2010).

At the center of the visible ferrite and pearlite phase similar to the raw material. This indicates that the center of the steel has a different hardness with the surface.

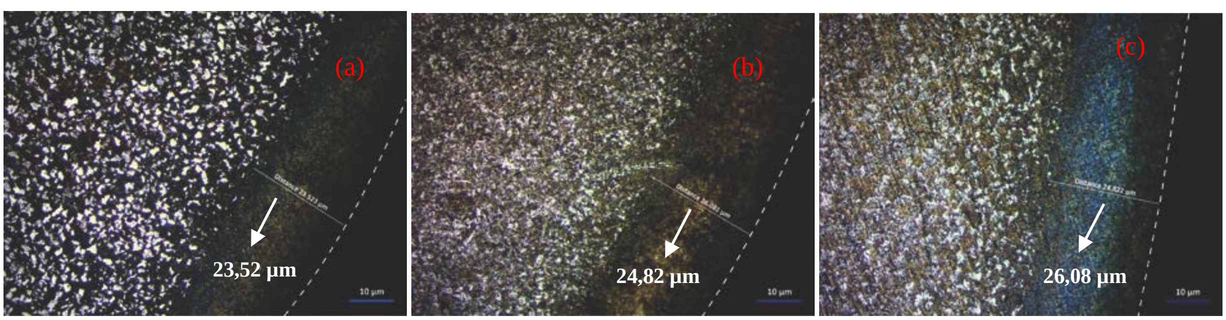

FIGURE 7. Material 1,5 hour (a) $BaCO_3$ 50 gr (b) $BaCO_3$ 75 gr (c) $BaCO_3$ 100 gr

After observing the microstructure of material with 1.5 hours duration on the variation of $BaCO_3$ composition, obtained the Figure 7. From the results of the image is also seen a layer of carbon on the surface. Carburizing carbon layer is greater when compared to specimens with pack carburizing for 1 hour. The longer the holding time is given, the more diffused carbon will be (Hafni, 2015). The results also show the phase difference due to good etching, so that the ferrite and pearlite phases are quite visible in the center of the steel. In the center will have a softer or ductile properties.

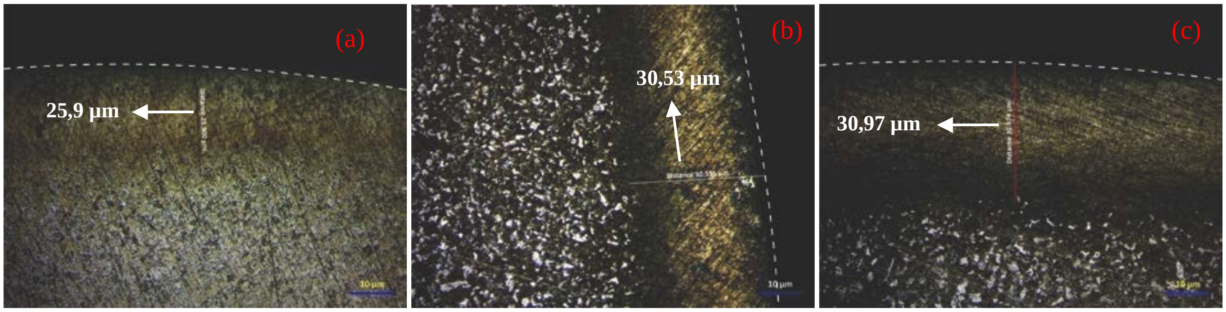

FIGURE 8. Material 2 hour (a) $BaCO_3$ 50 gr (b) $BaCO_3$ 75 gr (c) $BaCO_3$ 100 gr

After observation of microstructure of material with 2 hours hold time on variation of $BaCO_3$ composition, obtained figure 8. It appears that the three specimens formed a thick carburizing layer when compared to the 1 hour and 1.5 hour hold time. On the surface looks denser and also not visible ferrit phase, while in the middle visible phase ferrite and perlite. It is known that the thickest carbon layer, which is 30.9 micrometers.

From all the microstructure test images can be known the length of each layer of carbon produced on the material. The ratio of the thickness of each material to the treatment variation can be seen in the figure below. It can be seen that the more $BaCO_3$, the carburizing depth will be greater. This is due to increased carbon content due to increased carburizing effectiveness. On the graph in figure 9a can also be seen that the longer the hold time the thicker the deeper. This is due to the longer duration, the more it will be sufficient to diffuse the carbon atoms.

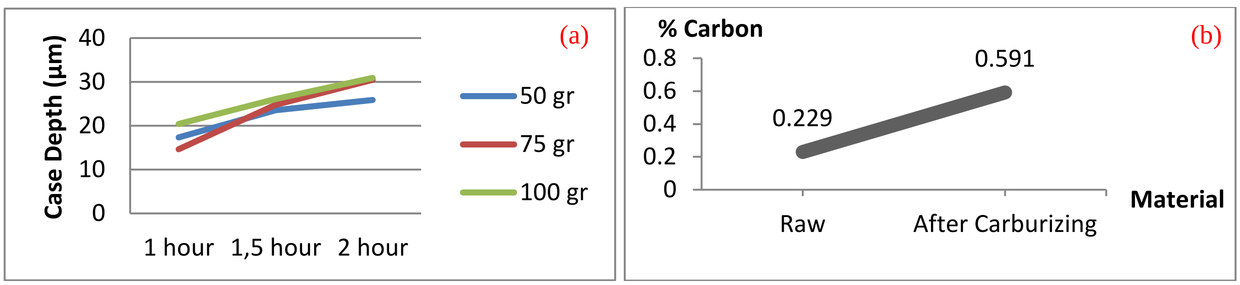

FIGURE 9. (a) Carburizing Layer (b) Carbon Content In ST 41 Steel

In the figure 9b it can be seen that the carbon content increases up to 0.591%. This shows that the mixture of bintaro fruit charcoal and coconut shell has succeeded in increasing the level of the cabon in the steel. Carbon formed in pyrolysis process can be used pack media carburizing. The lignicellulose content has reacted to break down into a high carbon-containing material (Maryono, Sudding, & Rahmawati, 2013).

CONCLUSION

Based on the results of this study can be concluded that

1. The value of surface hardness and jominy hardness on pack carburizing process using mixed bintaro charcoal and coconut shell medium increased every addition of holding time and composition of $BaCO_3$ with best result obtained by steel with 2 hours hold time and $BaCO_3$ 100 gr.
2. Microstructure test results show that each addition time and composition of $BaCO_3$ on pack carburizing process using mixed bintaro charcoal and coconut shell media, carburizing layer with abundant carbon formed and also seen the middle of steel has ferrite and pearlite phase.

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